Recently it has been found that malt if inoculated with a particular ferment from the skin of the grape will be converted into wine, the ferment used giving rise to the formation of characteristic ethers, so it is certainly not beyond the limits of possibilities that in the near future American beer after a voyage to France may return as excellent champagne. When we discover too a germ (as had been done recently) that converts starch into cellulose, we are almost led to wonder if it might not be possible to produce cotton in a culture flask if the particular germs were supplied with nutritious food and a sufficient amount of carbon dioxide, oxygen and water.

The flavor of many lucious fruits and foods is due to the products either directly or indirectly of one or more of these useful bacteria, and on the other hand similar germs play an important and as yet unknown rôle in the formation of poisonous alkaloids.

Many bacteria form beautifully colored substances, reds, yellows, blues, greens and delicate shades which the art of man has not been able to imitate and the nature of which he has not yet learned. These, too, are only hiding their secrets with a thin veil which investigation will soon withdraw.

But it is not only in simple industrial processes that the products of germs are important. Man's very existence, while menaced on the one hand by a few germs, is on the other dependent upon their activity. The germs which in the soil produce nitrous and nitric acid and ammonia, and aid their assimilation by the plants, those which facilitate the decomposition of phosphates and bring the phosphorous, a so necessary constituent for the life of plants and animals into an available form, and those which aid in the destruction of dead vegetable and animal matter, play a very valuable and but little appreciated part in the continuance of the life and well-being of man.

There are many other ways in which the products of these dreaded microscopic cells are useful, but all, a very insignificant number of which we have mentioned, are only waiting man's bidding to become valuable subjects, and to show that, as has been instanced in the history of nations, conquered people often make the best and wisest citizens.

E. A. DE SCHWEINITZ.

WASHINGTON, D. C.

THE GROWTH OF CHILDREN.

IN the years 1891 and 1892 I collected statistics on the growth of children in Worcester, Mass., mainly with a view to investigating individual growth. Although it was not possible, as was my original intention, to continue the series through a number of years, some results of interest have been obtained. The measurements were taken partly by myself, partly by fellows and students of Clark University. I am indebted to Dr. G. M. West for many of the measurements.

The stature of the same children was measured in May, 1891, and in May, 1892. The average annual increases and the variability of the amount of growth (the mean of the squares of individual variations) for these intervals were as follows:

AVERAGE INCREASES IN STATURE OF CHILDREN BETWEEN THE FOLLOWING YEARS (*cm.*).

	5 and 6	6 and 7	7 and 8	8 and 9	9 and 10	10 and 11	11 and 12	12 and 13	13 and 14	14 and 15	15 and 16
Boys	6.55	5.70	5.37	4.89	5.10	5.02	4.99	5.91	7.88	6.23	5.64
Girls	5.75	5.90	5.70	5.50	5.97	6.17	6.98	6.71	5.44	3.34	——

VARIABILITY OF ANNUAL GROWTH.

Boys	——	±0.68	±0.86	±0.96	±1.03	±0.88	±1.26	±1.86	±2.39	±2.91	±3.46
Girls	±0.88	±0.98	±1.10	±0.97	±1.23	±1.85	±1.89	±2.06	±2.89	±2.71	——

This table shows that young children grow more uniformly than older children. The increasing variability is very great during the years of adolescence. After this period it must necessarily fall. It disappears as soon as all the individuals have ceased growing. This increase in variability must be considered due to the effect of retardation and acceleration of growth. During the period preceding puberty some individuals will have reached their full growth, while others are still growing at a very rapid rate. As the rate of growth during the early years of childhood does not vary very much, retardation and acceleration will not have any effect of this sort. For the same reason the distribution of amounts of growth during the years preceding puberty is very asymmetrical and must be more so for the years from 17 to 20, for which I have no observations. It will be noticed that the growth of girls is more variable than that of boys.

I have furthermore divided the series for each year in two equal halves, the one embracing the tall children, the other embracing the short children. The average annual increases of these two groups are as follows:

AVERAGE INCREASE IN STATURE BETWEEN THE FOLLOWING YEARS:

	6 and 7	7 and 8	8 and 9	9 and 10	10 and 11	11 and 12	12 and 13	13 and 14	14 and 15	15 and 16
Short boys	5.5	5.2	4.8	4.8	4.8	4.8	5.2	7.3	7.5	6.8
Tall boys	5.9	5.5	5.0	5.4	5.3	5.2	6.6	8.5	5.0	4.4
Difference	+0.4	+0.3	+0.2	+0.6	+0.5	+0.4	+0.6	+1.2	—2.5	—2.4
Short girls	5.7	5.5	5.3	5.5	5.8	7.0	7.4	6.5	4.5	
Tall girls	6.1	5.9	5.6	6.4	6.5	7.0	6.0	4.4	2.2	
Difference	+0.4	+0.4	+0.3	+0.9	+0.7	0.0	—1.4	—2.1	—2.3	

It appears that during the early years of childhood short children grow more slowly than tall children, that is to say their general development continues to be slow. Later on, during the period of adolescence, they continue to grow while tall children have more nearly reached their full development. That is to say, small children are throughout their period of growth retarded in development, and smallness at any given period as compared to the average must in most cases be interpreted as due to slowness of development. During early life slowness of development which has manifested itself is likely to continue, while some of the effects of retardation will be made good during the period of adolescence, which is liable to be longer than in children who develop rapidly in early life.

We will call the average stature at the age t A_t; the amount of growth of an individual whose stature at that period is $A_t + x$ may be called d_x. We assume that the relation between the actual size of an individual and the average amount of its annual growth be expressed by the simple relation

$$d_x = d + ax$$

where a is a constant.

Furthermore we will assume that the variability of d_x will be the same for all values of x. Then it can easily be proved that

$$a = \sqrt{\frac{\mu_1^2 - m^2}{\mu^2}} - 1$$

where μ and μ_1 the variabilities of stature at the periods t and t_1 and where m the variability of the amount of growth during the period t_1–t.

From these data the following values of a have been computed:

Age.	Boys.	Girls.
6	0.05	0.05
7	0.05	0.05
8	0.01	0.01
9	0.03	0.03
10	0.06	0.06
11	0.06	0.07

Age.	Boys.	Girls.
12	0.10	—0.11
13	0.08	—0.17
14	—0.03	—0.20
15	—0.22	

The values cannot claim any great weight, since the series of observations is very small. Only about fifty individuals for each year and sex are available. They prove, however, that the values of a first decrease until about the eighth year. Then they increase and decrease again very rapidly after the thirteenth year in boys and after the eleventh year in girls.

According to the assumptions made before, the average individual which measured $A + x$ at the period t will measure

$$(A + x) + (d + ax) = A + d + x\frac{\mu_1}{\mu}\sqrt{1 - \frac{m^2}{\mu_1^2}}$$

at the period t_1.

If it measured

$$A + d + x\frac{\mu_1}{\mu},$$

it would remain in the same percentile grade while according to the above formula its percentile standing will be nearer the average than at the initial period t. Only when all the children of the initial measurement $A + x$ grow equally, *i. e.*, if $m = 0$ could they remain in the same percentile grade. This conclusion agrees with Dr. Henry G. Beyer's observations.*

The above approximation is fairly satisfactory during the early years of childhood. During the period of adolescence it is not satisfactory, because the values of a are too large. More extended observations will enable us to include terms of higher order in the considerations and to obtain more accurate knowledge of the laws of growth.

The results of this investigation suggest that the differences of growth observed in children of different nationalities and of parents of different occupations may also be partly due to retardation or acceleration of growth, partly to differences of development in the adult stage.

In order to decide this question we may assume that in the averages obtained for all the series representing various social groups accidental deviation from the general average only occurred. Then it is possible to calculate the average deviation which would result under these conditions. When the actual differences that have been found by observation are taken into consideration another average deviation results. If the latter nearly equals the former, then the constant causes that affect each social group are few and of slight importance. If it is much larger than the former, then the causes are many and powerful. The proportion between the theoretical value of the deviation and the one obtained by observation is therefore a measure of the number and value of the causes influencing each series.

I have applied these considerations to the measurements of Boston school children obtained by Dr. H. P. Bowditch. I have used thirteen different classes in my calculations, namely, five nationalities: American, Irish, American and Irish mixed, German and English; and eight classes grouped according to nationalities and occupations: American professional, mercantile, skilled labor and unskilled labor, and the same classes among the Irish.

The results are as follows:

	Boys. Deviation.			Girls. Deviation.		
Age.	Theory.	Obs.	Ratio.	Theory.	Obs.	Ratio.
5	0.34	0.34	1.0	0.40	0.58	1.5
6	0.28	0.46	1.6	0.34	0.57	1.8
7	0.29	0.76	2.6	0.32	0.81	2.5
8	0.28	0.54	1.9	0,30	0.71	2.4
9	0.32	0.89	2.7	0.36	0.40	1.1
10	0.33	0.76	2.4	0.38	0.83	2.1
11	0.35	1.05	3.0	0.46	1.04	2.2
12	0.40	1.18	3.0	0.52	1.89	3.6
13	0.46	1.65	3.6	0.52	1.44	2.8
14	0.57	2.69	4.7	0,53	0.98	1.9
15	0.67	2.06	2.9	0.53	1.02	1.9
16	0.72	1.50	2.1	0.54	0.53	1.0

* Proc. U. S. Naval Institute, Vol. XXI., No. 2.

We see that the values obtained by actual observation are always greater than those obtained under the assumption that only accidental causes influence the averages for each class. We also see that these causes reach a maximum during the period of growth and decrease as the adult stage is reached. The maximum is found in the fourteenth year in the case of boys, in the twelfth year in the case of girls, *i. e.*, in those years in which the effects of acceleration and retardation of growth are strongest. Although the values given here cannot claim any very great weight on account of the small number of classes, this phenomenon is brought out most clearly.

The figures prove, therefore, that the differences in development between various social classes are, to a great extent, results of acceleration and retardation of growth which act in such a way that the social groups which show higher values of measurements do so on account of accelerated growth, and that they cease to grow earlier than those whose growth is in the beginning less rapid, so that there is a tendency to decreasing differences between these groups during the last years of growth.

FRANZ BOAS.

THE PROMISE AND POTENCY OF HIGH-PRESSURE STEAM.

THE writer has been so fortunate, recently, as to be permitted to study the action of exceptionally high-pressure steam in the engine, under favorable conditions, and thus to add to the record of Jacob Perkins and his sons, and of Dr. Albans and others experimenting with steam of extraordinarily high-pressure, data which represents much more satisfactorily the conditions now known by the engineer to be those essential to economic operation.*

The progress made to date and during the century now elapsed since the introduction by James Watt of the modern type of steam-engine, as adapted to the performance of every variety of work, has been mainly through the steady advances effected in the successful management and application of steam of increasing pressure, with corresponding thermodynamic gain by increasing the ratio of expansion, and with reduction of wastes, mainly by increasing speeds of engine. The accessory gains have been through expedients for improving the lubrication, to reduce wastes of dynamic energy, and for securing better protection against external losses of thermal energy, and improvements, as by jacketing and superheating, resulting in suppression of the internal condensation, due to the action of the cylinder wall.

Increasing steam pressure gives increased mean effective pressures, and rising temperatures of steam afford gains by widening the range of adiabatic and thermodynamic transformation of energy. Superheating has not, as yet, been successfully carried so far as to permit increased thermodynamic transformation by providing a steam gas as the working fluid in the engine. It practically simply insures dryer, and thus better, working steam. Up to the present time the risings, temperatures and expansions have gone together, being limited by the conditions which give us dry and saturated steam. The result has been a steady advance for a century, both in the 'duty' of the machine and its complementary elements, thermodynamic and mechanical efficiency. Watt insisted on restricting steam pressure to seven pounds per square inch on the score of safety ; we now employ from twenty to thirty times that pressure with probably no greater risk. The work described in the communication here abstracted was done at 300 to 500 pounds pressure, and the boiler employed had been

*The 'Promise and Potency' of high-pressure steam; illustrated by the performance of the triple, and the quadruple-expansion experimental engines of Sibley College. Trans. Am. Soc. M. E., December, 1896. Vol. XVIII; No. DCCXVIII.